


Potential for Accelerating Response Complete (RC) at Petroleum Sites in the Navy's Portfolio

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Which sites in the Navy's portfolio would you close first, if you had a choice?

- High-risk sites**
 - Strong source
 - Plume that migrates far from source or is still migrating
 - Contaminants that don't degrade well under different aquifer conditions
- Low-risk sites**
 - Weak source (or source that has weathered over time)
 - Plume that does not migrate far from source and is stable or receding
 - Contaminants that degrade under all aquifer conditions


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Which sites best meet the criteria for low-risk sites?

- Chlorinated solvent sites
- Sites with petroleum hydrocarbons
- Sites with PCBs


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Do petroleum sites have the characteristics of low-risk sites?

- Weak source (or source that has weathered over time)
 - Has LNAPL stopped migrating on its own?
 - Is the source degrading naturally?
- Plume
 - that does not migrate far from source,
 - and is stable or receding
- Contaminants that degrade under all aquifer conditions
 - Aerobic conditions
 - Anaerobic conditions


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Is there a difference between "mobile" NAPL and "migrating" NAPL?

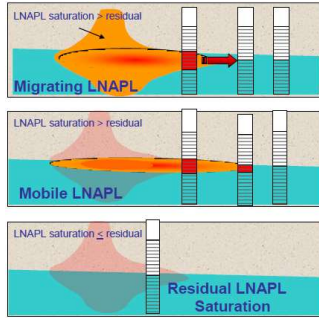
- Yes, I know the difference
- No, I think they are the same

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Has LNAPL stopped migrating on its own?

- What is the difference between mobile and migrating product?
 - Transmissivity measurements
- What is the difference between mobile and residual product?
 - Appears in wells or not



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<p>Is the source degrading naturally? -- How many sites are collecting free product in wells at rates comparable to the natural depletion rates below?</p>	
NSZD Study	Site-Wide NSZD Rate (gallons per acre per year)
Six Refinery Terminal Sites (McCoy, 2012)	2,100 – 7,700
1979 Crude Oil Spill (Sihota et al., 2011)	1,600
Refinery/Terminal Sites in Los Angeles (LA LNAPL Wkgrp, 2015)	1,100 – 1,700
Five Fuel/Diesel/Gasoline Sites (Piontek et al, 2014)	300 - 3,100
Eleven Diverse Petroleum Sites (Palaia, 2016)	300 – 5,600

7

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Once the lighter aromatics have degraded, is the weathered product still toxic?

TPH Criteria Working Group Method

- API, 2001
- Hundreds and thousands of individual compounds in TPH
- Not all are toxic

Aliphatics

nC_6

$>nC_6, nC_7$

$\geq nC_8, nC_{10}$

$\geq nC_{10}, nC_{12}$

$\geq nC_{12}, nC_{14}$

$\geq nC_{14}, nC_{16}$

$\geq nC_{16}, nC_{18}$

$\geq nC_{18}, nC_{20}$

$\geq nC_{20}, nC_{22}$

$\geq nC_{22}, nC_{24}$

$\geq nC_{24}, nC_{26}$

$\geq nC_{26}, nC_{28}$

$\geq nC_{28}, nC_{30}$

Aromatics

$2nC_7, nC_8$ (Toluene)

$2nC_8, nC_9$

$2nC_{10}, nC_{11}$

$2nC_{11}, nC_{12}$

$2nC_{12}, nC_{13}$

$2nC_{13}, nC_{14}$

$2nC_{14}, nC_{15}$

$2nC_{15}, nC_{16}$

$2nC_{16}, nC_{17}$

$2nC_{17}, nC_{18}$

$2nC_{18}, nC_{19}$

$2nC_{19}, nC_{20}$

$2nC_{20}, nC_{21}$

$2nC_{21}, nC_{22}$

$2nC_{22}, nC_{23}$

$2nC_{23}, nC_{24}$

$2nC_{24}, nC_{25}$

$2nC_{25}, nC_{26}$

$2nC_{26}, nC_{27}$

$2nC_{27}, nC_{28}$

$2nC_{28}, nC_{29}$

$2nC_{29}, nC_{30}$

Adapted from Rhodes, 2006

8

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Is the benzene plume one that does not migrate far from source?
Is the benzene plume stable or receding?

- For plumes delineated to a 10 µg/L concentration limit the median lengths of benzene plumes (826 sites) fall within the range of 101 to 185 feet

What about emerging contaminants? MTBE? 1,2 DCA? EDB???

- The median lengths of MTBE plumes (391 sites) fall within a slightly narrower range of 110 to 178 feet
- At the 90th percentile, MTBE plumes were 25% longer

Sources cited in California Low-Threat Closure Guidance: Rice, et al. 1995; Rice et al. 1997; Bushech et al. 1996; Mace, et al. 1997; Groundwater Services, Inc. 1997; API 1998; Dahlen et al. 2004; Shih et al. 2004; Kamath et al. in press

9

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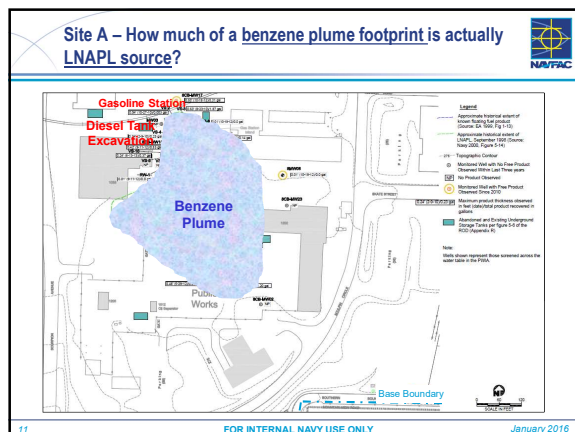
Why are benzene (or BTEX) plumes not very long?

Does benzene biodegrade naturally under:

- Aerobic conditions?
- Yes
- Mildly anaerobic (nitrate-reducing) conditions?
- Yes
- Moderately anaerobic (iron-reducing) conditions?
- Yes
- Strongly anaerobic (sulfate reducing) conditions?
- Yes
- Very strongly anaerobic (methanogenic) conditions?
- Yes

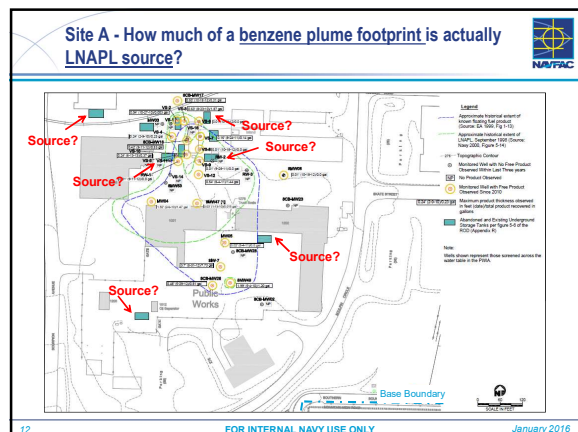
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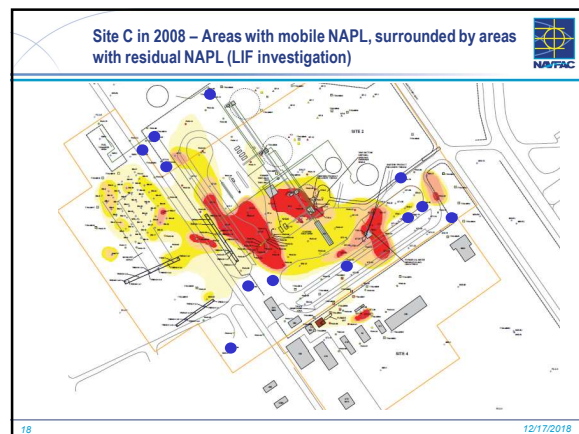
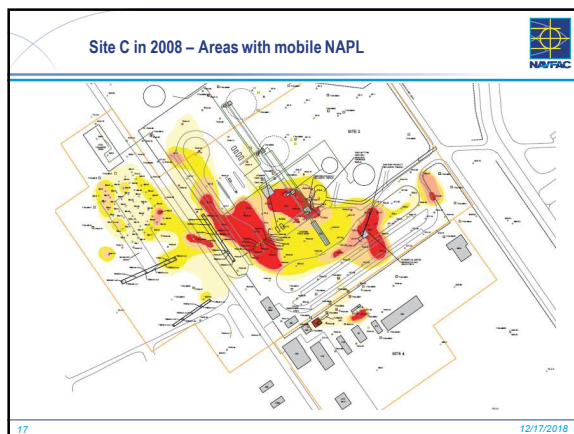
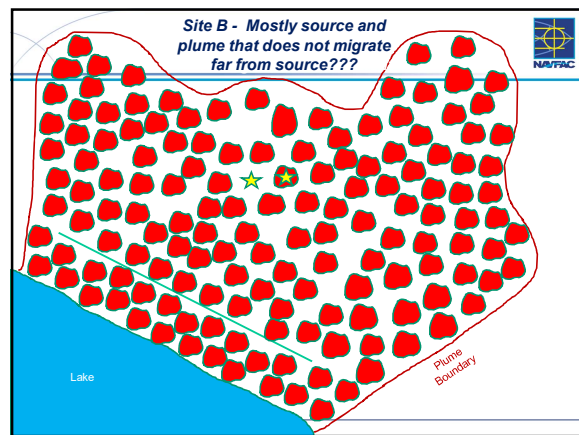
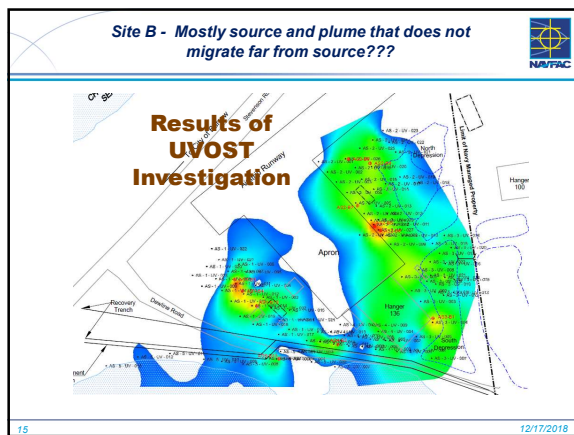
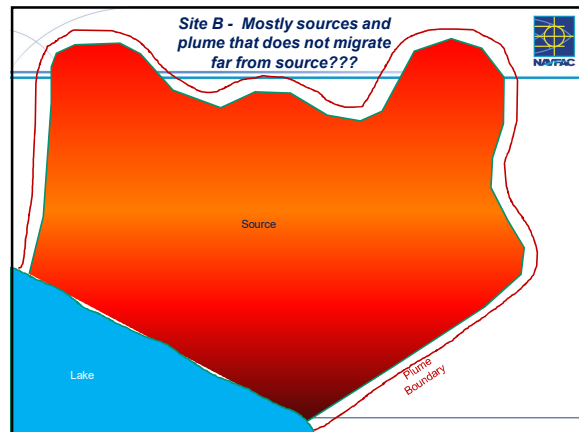
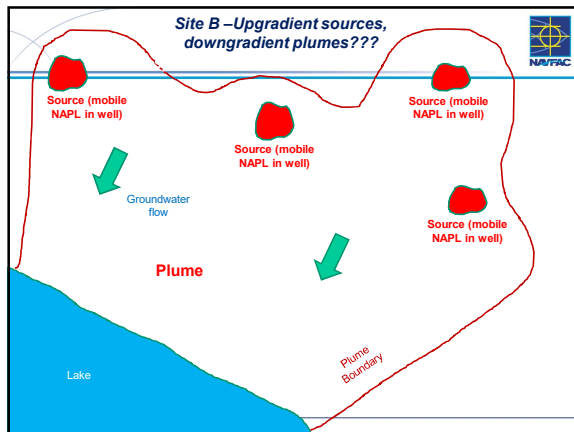
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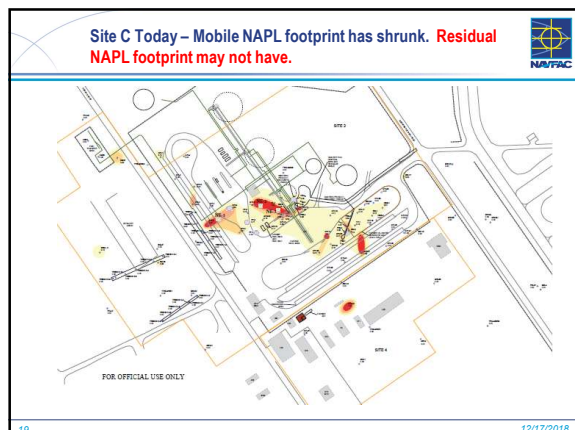
January 2016



12

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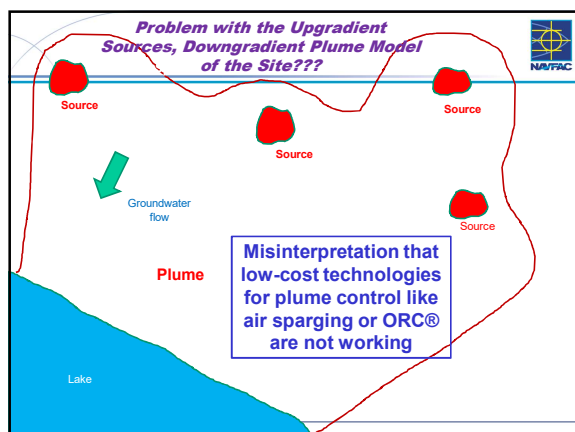
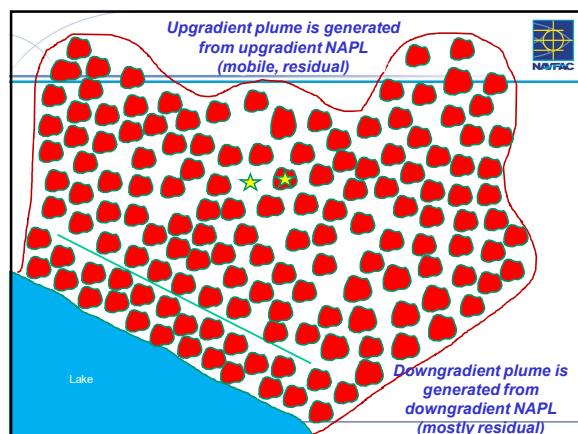
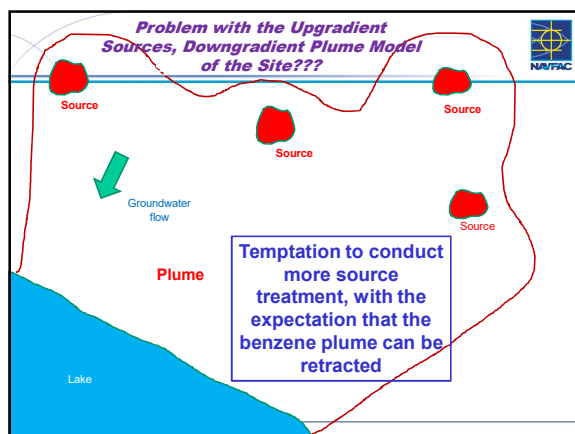




Key Points

- Often, the benzene plume is a good approximation of the historical NAPL distribution
- Wherever there is benzene, residual NAPL may not be far away
- The “source” of the benzene plume is not the ring of wells in which free product still appears

20 12/17/2018



Are petroleum sites low-risk sites, ready for closure?

California Low-Threat Closure Guidance

- A total separation distance from the source area to the receptor of about 500 feet should be protective for 90% of plumes from UST sites, and a total separation distance from the source area to the receptor of about 1,000 feet should be protective for virtually all plumes from UST sites
- A time period of multiple decades or longer to reach WQOs has been determined to be “reasonable” for plumes of limited extent in existing State Water Board closure orders for UST sites

24 12/17/2018

For petroleum sites, good outcomes would be...
(in order of preference)



1. **Site closure (SC) – no LUCs**
2. **Response Complete (RC) – LUCS only (maybe LTM to verify plume stability)**
3. **MNA – LTM to verify decreasing concentrations**

4. **Skimmers, MNA**